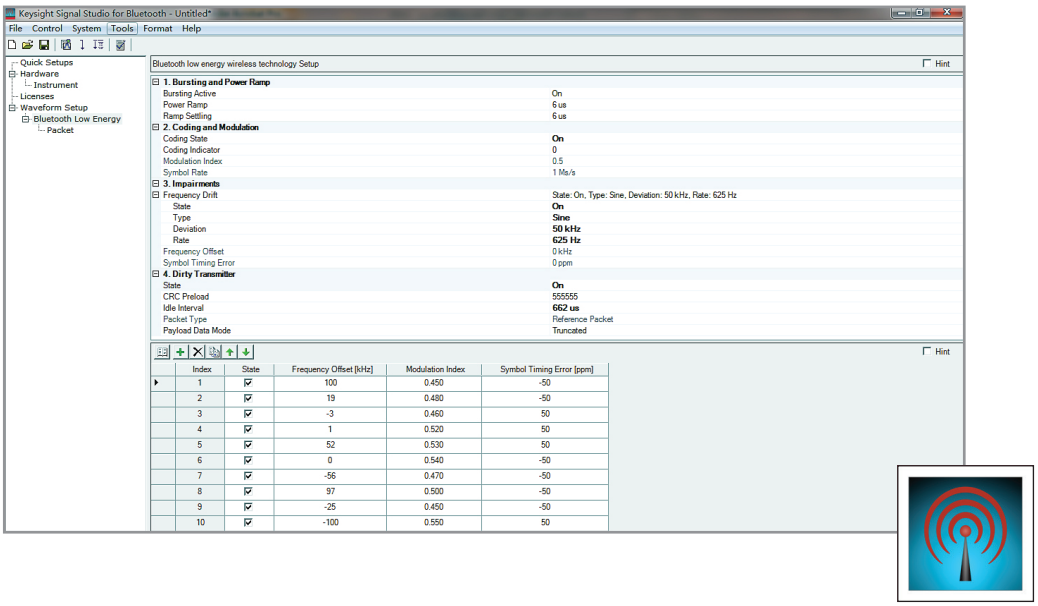
Keysight Technologies

Signal Studio for *Bluetooth*®

N7606B

Technical Overview



- Create Keysight validated and performance optimized reference signals compliant to *Bluetooth* BR (basic rate), EDR (enhanced data rate), LE (low energy) 4.0, LE 4.2 (longer packet length), LE 5.0 (higher data rate and longer range)
- Utilize fully-coded *Bluetooth* packets and modulated data streams for both basic and enhanced data rates
- Support data length extension to 255 bytes for *Bluetooth* LE 4.2
- Support 2Ms/s symbol rate for higher data rate and channel coding for long range for *Bluetooth* LE 5.0
- Use dirty transmitter test setup for receiver sensitivity tests with DHx, 2-DHx, 2-EVx, 3-DHx and 3-EVx packet types
- Accelerate the signal creation process with a user interface based on parameterized and graphical signal configuration and tree-style navigation

KEYSIGHT TECHNOLOGIES

Simplify *Bluetooth* Signal Creation

Keysight Signal Studio software is a flexible suite of signal-creation tools that will reduce the time you spend on signal simulation. For *Bluetooth*, Signal Studio's performance-optimized reference signals—validated by Keysight—enhance the characterization and verification of your devices. Through its application-specific user-interface you'll create standards-based and custom test signals for component, transmitter, and receiver test.

Component and transmitter test

Signal Studio's basic capabilities use waveform playback mode to create and customize waveform files needed to test components and transmitters. Its userfriendly interface lets you configure signal parameters, calculate the resulting waveforms and download files for playback. The applications for these partiallycoded, statistically correct signals include

- Parametric test of components, such as amplifiers and filters
- Performance characterization and verification of RF sub-systems

Receiver test

Signal Studio's advanced capabilities enable you to create fully channel-coded signals for receiver bit-error-rate (BER), block-error-rate (BLER), packet-error-rate (PER), or frame error rate (FER) analysis. Applications include

- Performance verification and functional test of receivers, during RF/baseband integration and system verification
- Coding verification of baseband subsystems, including FPGAs, ASICs, and DSPs

Apply your signals in real-world testing

Once you have setup your signals in Signal Studio, you can download them to a variety of Keysight instruments. Signal Studio software complements these platforms by providing a cost-effective way to tailor them to your test needs in design, development and production test.

Vector signal generators
- X-Series: N5182A/B MXG and N5172B EXG
- E8267D PSG
- E4438C ESG
- M9381A PXIe VSG

EXM wireless communication test set
EXT wireless communication test set
SystemVue simulation software
Waveform Creator software

Typical Measurements

Test components with basic capabilities

- IMD/NPR
- ACLR
- CCDF
- EVM
- Modulation accuracy
- Channel power
- Occupied bandwidth

Verify receivers with advanced capabilities

- Sensitivity
- Maximum input level
- Selectivity
- Blocking
- Intermodulation

Component and Transmitter Test

Figure 1. Typical component test configuration using Signal Studio's basic capabilities with a Keysight X-Series signal generator and an X-Series signal analyzer

Signal Studio enables you to create and customize *Bluetooth* waveforms to characterize the power and modulation performance of your components. The simple user interface allows you to create standards-based *Bluetooth* packets and modulated data streams for *Bluetooth* BR (basic rate), EDR (enhanced data rate), LE (low energy) 4.0, 4.2 (longer packet length), 5.0 (higher data rate and longer range).

- Create signals for ACLR, channel power, spectral mask, and spurious testing
- Set parameters such as channel power, link type and modulation type for modulation verification and analysis, such as EVM tests
- View CCDF, spectrum and time domain graphs to investigate the effects of power ramps, modulation formats, power changes, and other effects on device performance

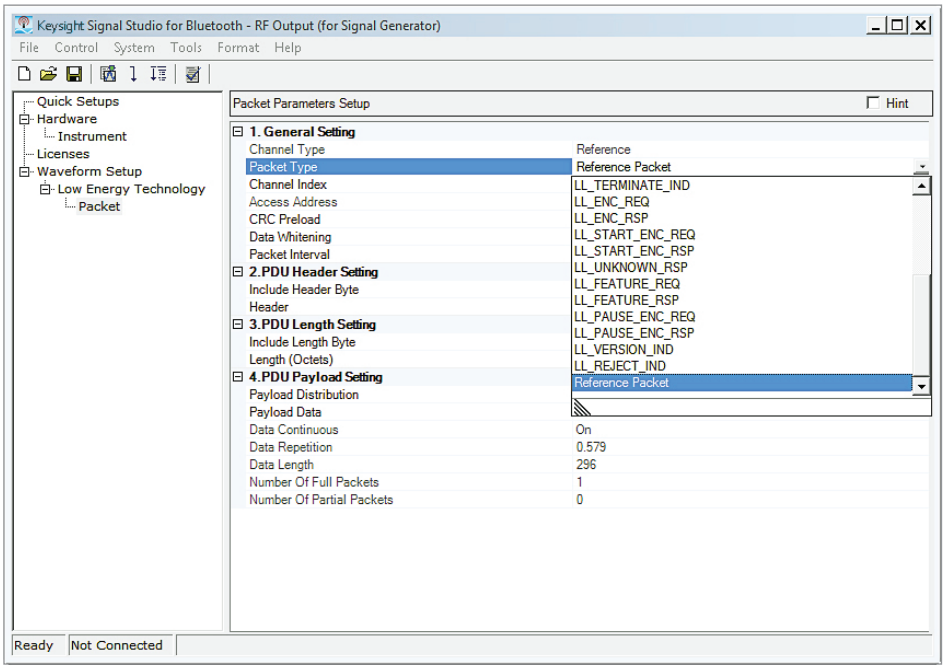


Figure 2. *Bluetooth* low energy packet configuration

Receiver Test

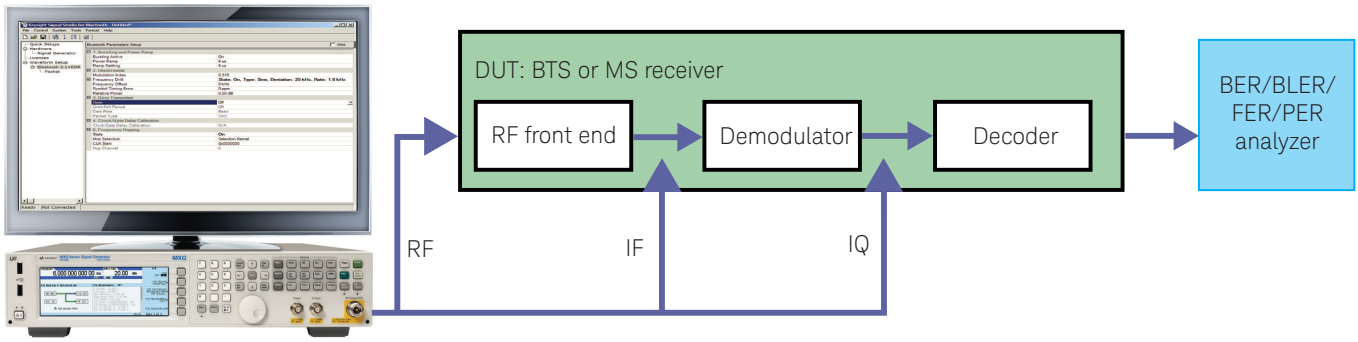


Figure 3. Generate fully channel-coded signals to evaluate the BER, BLER, PER, or FER of your receiver with Keysight X-Series signal generators and Signal Studio's advanced capabilities

Signal Studio's advanced capability allows you to create fully-coded *Bluetooth* signals with a variety of different packet types and PDU settings. Choose continuous PN data patterns for BER analysis, or select user-defined data patterns or custom user files for the data packets. Frequency hopping can be configured in the baseband waveform for *Bluetooth* BR and EDR with selection kernel sequence or user-defined hopping sequence. Signal impairments such as dirty transmitter, carrier frequency offset, symbol timing error, frequency drift, relative power offsets, and AWGN can also be added.

To simplify BER test setup, an automated clock/gate/payload delay optimization routine is provided in the software for use with the E4438C ESG signal generator. Using the routine, the data, clock, and gate signal timing alignment at the input of the ESG's internal BER analyzer (Option UN7) is easily determined and modified to ensure accurate test results.

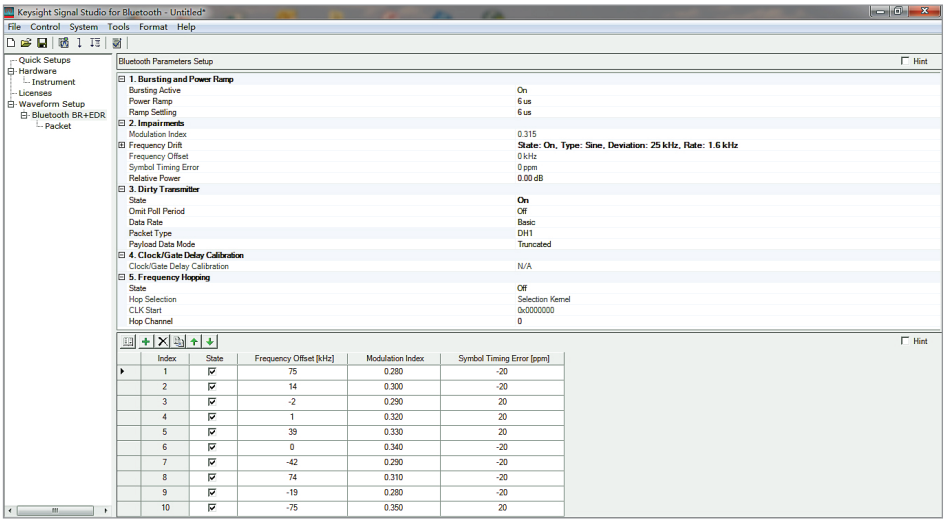


Figure 4. Configure impairments such as dirty transmitter and frequency drift for Bluetooth EDR transceiver test.

Features Summary

Bluetooth	**Component and receiver testing**
	Advanced waveform playback mode
Bluetooth BR+EDR	– Bursting on/off – Power ramp and ramp settling time – Impairments – Modulation index – Frequency drift -- Type: Linear, sine -- Deviation: -100 kHz to 100 kHz -- Rate: 300 Hz, 500 Hz, 1.6 kHz, 10 kHz – Frequency offset: -100 kHz to 100 kHz – Symbol timing error – Dirty transmitter setup – Include or omit poll period – Packet type: DH1, DH3, DH5 – Predefined test profile or add custom impairment sets with frequency offset, modulation index, and symbol timing error – Packet parameter setup – Link type: SCO, ACL – Packet type: NULL, POLL, FHS, DM1, DM1, DH1, HV1, HV2, HV3, DV, AUX1, DM3, DH3, DM5, DH5, ID – Modulation: GFSK (BT=0.5) – Packet data type: Use standard packet type or raw data only – Set *Bluetooth* device address (BD_ADDR: LAP, UAP, NAP), active member address (AM_ADDR) – Flow control bit, ARQ control bit, sequential number index – Payload parameter setup – Single or multiple packet – LLID, flow indicator – Payload data length and data types: PN9, PN15, user-defined – Data whitening on/off – Dirty transmitter setup – Data rate: basic, 2 Mbps, 3 Mbps – Packet type: 2-DH1, 2-DH3, 2-DH5, 2EV-3, 2EV5, 3-DH1, 3-DH3, 3-DH5, 3EV-3, 3EV-5 – Predefined test profiles – Frequency hopping – Hop selection: Selection kernel, user defined – CLK start – Packet parameter setup – Link type: SCO (basic data rate), eSCO (basic or enhanced data rate), ACL (basic or enhanced data rate) – Packet type: 2-DH1, 3-DH1, 2-DH3, 3-DH3, 2-DH5, 3-DH5, EV3, 2-EV3, 3-EV3, EV4, EV5, 2-EV5, 3-EV5 – Modulation: GFSK (BT=0.5) + DQPSK (2 Mbps), GFSK (BT=0.5) + D8PSK (3 Mbps)

Bluetooth low energy (version 4.0 and 4.2)	– Bursting on/off – Power ramp and ramp settling time – Impairments – Modulation index – Frequency drift -- Type: Linear, sine -- Deviation: -100 to 100 kHz -- Rate: 750 Hz, 625 Hz – Frequency offset: -100 kHz to 100 kHz – Symbol timing error – Dirty transmitter setup – Truncated or continuous reference packet – Variable packet interval – Packet parameter setup – Packet types -- Reference channel: Reference -- Advertising channel: Adv_Ind, Adv_Direct_Ind, Adv_Nonconn_Ind, Adv_Scan_Ind, Scan_Req, Scan_Rsp, Connect_Req, -- Data channel: LL_Data, LL_Connection_Update_Req, LL_Channel_Map_Req, LL_Terminate_Ind, LL_Enc_Req, LL_Enc_Rsp, LL_Start_Enc_Req, LL_Start_Enc_Rsp, LL_Unknown_Rsp, LL_Feature_Req, LL_Feature_Rsp, LL_Pause_Enc_Req, LL_Pause_Enc_Rsp, LL_Version_Ind, LL_Reject_Ind, Reference -- Packet modulation: GFSK (BT=0.5) – Packet settings: Channel index, access Address, CRC preload, data whitening, packet interval – PDU header settings – Packet type dependent: Public state of advertiser address, scanner address, and initiator address; logical link (LL) data or control, NESN (sequence number of next expected packet), SN (sequence number), MD (more data bit), include header byte, header value – Payload parameter setup – Packet type dependent: Advertiser address, scanner address, profile ID, more profile indication bit, encrypted request bit, advertiser name, initiator address, logical link connection access address, CRC initialization, hop length, channel map, sleep clock accuracy, pairing identity, encrypted mode, key diversifier, control type, interval, latency, timeout, LL connection event count – Single or multiple packet – Payload data length and data types: PN9, PN15, user-defined – Payload length is extended to 255 bytes for version 4.2
Bluetooth low energy (version 5.0)	– Supports channel coding for long range – Supports higher symbol rate for 2Ms/s

Supported Standards

Version	Bluetooth Special Interest Group specification	IEEE specification	Adoption date
Bluetooth 1.1	Core version 1.1	802.15.1-2002 802.15.1-2005	2002 2005
Bluetooth 2.1 + EDR	Core version 2.1 + EDR		July 2007
Bluetooth low energy	Core version 4.0 Core version 4.2 Core version 5.0		June 2010 December 2014 August 2015 (Prototyping)

Performance Characteristics

Definitions

Measured (meas):

An attribute measured during the design phase for purposes of communicating expected performance. This data is not warranted and is measured at room temperature (approximately 25 °C).

The following measured performance characteristics apply after execution of an I/Q calibration when the instrument is maintained within ± 5 °C of the calibrated temperature.

Link type	Parameters		Characteristic		N5172B EXG, N5182A/B MXG	M9381A	E4438C ESG
ACL (Basic data rate)	Packet type	DH1	FSK error		0.60%	0.65%	0.79%
	Modulation type	GFSK (BT = 0.5)					
	Packet data type	Standard					
	Frequency	2402 MHz					
	Amplitude	–10 dBm					
ACL (Enhanced data rate)	Packet type	3-DH1	ACP at frequency = 2402 + k MHz	K = 2	–68 dBm	–68.75 dBm	–65.95 dBm
	Modulation type	GFSK (BT = 0.5) + D8PSK					
	Packet data type	Standard		K = 3,4,5,...,78	–71 dBm	–75.40 dBm	–71 dBm
	Frequency	2402 MHz					
	Amplitude	–10 dBm					
LE (low energy)	Packet type	Reference	FSK error		0.39%[1]	–	–
	Symbol rate	2Ms/s					
	Modulation type	GFSK (BT = 0.5)					
	Payload	Single packet					
	Frequency	2.404 GHz					
	Amplitude	–10 dBm					

1. This specification only applies to the N5182B

Ordering Information

Software licensing and configuration

Signal Studio offers flexible licensing options, including:

- **Fixed license:** Allows you to create unlimited I/Q waveforms with a specific Signal Studio product and use them with a single, specific platform.
- **Transportable/floating license:** Allows you to create unlimited I/Q waveforms with a specific Signal Studio product and use them with a single platform (or PC in some cases) at a time. You may transfer the license from one product to another.
- **Waveform license:** Allows you to generate up to 545 user-configured I/Q waveforms with any Signal Studio product and use them with a single, specific platform.

The table below lists fixed, perpetual licenses only; additional license types may be available. For detailed licensing information and configuration assistance, please refer to the Licensing Options web page at **www.keysight.com/find/SignalStudio_licensing**

N7606B Signal Studio for *Bluetooth*

Model-Option	Description
Connectivity	
N7606B-1FP	Connect to E4438C ESG
N7606B-2FP	Connect to E8267D PSG
N7606B-3FP	Connect to N5182/62 MXG, N5172 EXG
N7606B-6FP	Connect to N5106A PXB
N7606B-7FP	Connect to Keysight simulation software
N7606B-8FP	Connect to E6607 EXT
N7606B-9FP	Connect to M9381A, E6630A
Capability	
N7606B-RFP[1]	Advanced *Bluetooth* BR + EDR
N7606B-SFP	Advanced *Bluetooth* low energy 4.0
N7606B-TFP	Advanced *Bluetooth* low energy 5.0 (requires N7606B-SFP)

1. N7606B-QFP is combined into N7606B-RFP.

Try Before You Buy!

Free 30-day trials of Signal Studio software provide unrestricted use of the features and functions, including signal generation, with your compatible platform. Redeem a trial license online at

www.keysight.com/find/SignalStudio_trial

Hardware configurations

To learn more about compatible hardware and required configurations, please visit: **www.keysight.com/find/SignalStudio_platforms**

PC requirements

A PC is required to run Signal Studio. **www.keysight.com/find/SignalStudio_pc**

Signal Studio Software Updates

To update previously purchased N7606B software to include the latest feature updates, you can purchase the N7606B-MEU minor enhancement update fixed perpetual license.

For more information, visit

www.keysight.com/find/N7606B-MEU

Additional Information

Websites

www.keysight.com/find/SignalStudio

Access the comprehensive online documentation, which includes the complete software HELP

www.keysight.com/find/n7606b
www.keysight.com/find/signalstudio

Keysight's GSM design and test solutions

www.keysight.com/find/bluetooth

Literature

Bluetooth Measurement Fundamentals, Application Note, 5988-3760EN

Signal Studio Software, Brochure, 5989-6448EN

Test Solutions for Greater Insight into Wireless Connectivity, Application Note, 5990-9072EN

www.keysight.com/find/n7606b

KEYSIGHT TECHNOLOGIES

Published in USA, December 5, 2017
5990-9097EN
www.keysight.com